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Edited by

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EDITORIAL

CHAIRMANSHIP OF THE TEA RESEARCH INSTITUTE BOARD

It will be learnt with much regret that Mr. James Forbes, who is shortly proceeding on leave out of Ceylon, vacates the Chairmanship of the Tea Research Institute Board as from the 31st December, 1940. Mr. Forbes has been a member of the Board since 1930, and has held the office of Chairman since January, 1934. Mr. Forbes' work in many spheres of planting activity is well known to all planters, but only those who have been intimately concerned with the work of the Institute can be aware of the enthusiasm he has shewn in the conduct of the Chairmanship and the great amount of time and energy he has devoted to the affairs of the Institute.

The Scientific Staff of the Institute moreover owe him a deep debt of gratitude for the keen interest he has shewn in the very varied aspects of their technical work and the unfailing support and encouragement he has at all times extended to them.

All those connected with the tea industry in Ceylon will join with us in wishing Mr. Forbes a pleasant leave and a safe return to the Island.

It is a matter of satisfaction that Mr. T. B. Panabokke, First Adigar, has accepted the unanimous invitation of the Board to assume the Chairmanship, at any rate for a limited period. Mr. Panabokke who was one of the original members of the Board has served on it for many years. He is therefore intimately acquainted with the work of the Institute in which he has always taken the keenest interest.

VISIT BY THE DIRECTOR TO INDIAN RESEARCH STATIONS

The Director who was on leave in India from August 9th to December 1st, 1940, took advantage of this opportunity to visit the Tocklai Experimental Station, Assam, and the U.P.A.S.I. Tea Research Station at Devarshola, South India. Visits were also made to tea estates in Assam, Darjeeling, and South India. Problems common to the three Research Stations were discussed and, in particular, the question of the joint research on the chemistry of tea which is being carried out in England was reviewed.

In the view of the authors, however, the manurial effect of the fallen leaves is of much more importance economically than the shading effect of the canopy and they consider that by the use of leguminous varieties a considerable saving in applied manures can be effected. They rightly point out, however, that in the presence of abundant soil nitrogen, fixation of atmospheric nitrogen by leguminous plants is likely to be reduced and there must therefore be an economic optimum density of shade for every rate of application of nitrogenous manures. It is this optimum which their experiments are designed to discover.

MILITARY SERVICE

The many friends of Dr. Tubbs, or Captain Tubbs as he should perhaps be designated in present circumstances, will be glad to know that he has fully recovered from wounds received in France earlier in the year. Captain Tubbs is now back with his regiment "somewhere in England." The Institute is likely shortly to lose the services "for the duration" of Mr. Redman King who has been selected for a commission in the Administrative Branch of the Royal Air Force Volunteer Reserve.

Mr. R. L. Illankoon, who received a commission in the Ceylon Light Infantry earlier in the year, has been mobilised and on military duty in Ceylon since August last.

In view of the above circumstances and the calls of military training, etc. on the time of other officers, it will be appreciated that some dislocation in the work of the Institute must ensue. In particular, the time available to the remaining officers for visits to estates will be limited and *The Tea Quarterly* may have to be somewhat reduced in volume.

ROLAND V. NORRIS.

POTASH DEFICIENCY IN TEA CULTIVATION

(REVIEW)

T. E. T. BOND

A recent publication* by I. de Haan and A. F. Schoorel, from the Proefstation West Java, Buitenzorg, draws attention to the discovery of a disease in tea caused by a deficiency of potash in the soil.

This might seem surprising in view of the fact that potash fertilisers have only rarely been found to give increased yields of tea and have often actually depressed the yield. As the authors point out, however, experiments in the past have largely been carried out, in Java at least, on relatively young volcanic soils with a high reserve of potash and other minerals, whereas the deficiency disease has been detected so far only on a group of soils of different age and origin, in which, owing to prolonged weathering, the mineral reserves are relatively low.

The disease first became apparent about three years ago, when various firms in West Java reported a serious local deterioration in the plantations over a wide area. Chemical analysis of soil and leaves indicated the nature of the problem, since marked differences in potash content occurred between samples from healthy and affected localities. Symptoms agreeing with those observed in the field were reproduced in pot cultures under conditions of known potash deficiency, artificially induced. The complex relationship between the appearance of deficiency symptoms and the potash content of the leaf and amount of available potash in the soil has been fully worked out, while manuring with potash fertilisers has been shown to eliminate the disease in the field and to effect a great improvement in the general condition of affected plantations.

The symptoms of the disorder in tea bear a close resemblance to those which are known to occur under similar conditions in other plants, as for instance, in the "leaf scorch" disease of apple and other fruit trees. Affected tea bushes appear backward and poorly developed, due to the premature defoliation of the lower leaves, particularly towards the base of the plant. Branches which have lost their leaves in this way continue to form new ones at the top

* Archief voor de Theecultuur, Vol. 14, pp. 43-81. (September, 1940).

but as might be expected, the flush growth is considerably less vigorous than in a healthy bush. The lateral buds also fail to develop, so that the stems tend to remain unbranched. The leaves are usually dull green in colour and less glossy than the normal. When they are fully grown, the colour becomes darker still and may be replaced by a bronzed appearance, particularly along the margins and at the tips. These parts of the leaf eventually dry out completely and by their grey or brown colour give rise to the characteristic "scorched" effect. Often the drying out of the leaf margin is followed immediately by fungal attack and in fact it appears that typical grey blight (*Pestalozzia*) symptoms may sometimes be developed as a response to potash deficiency. In severe cases of the disease, the leaves tend to be crumpled or curled downwards along the midrib in addition to showing the other symptoms. The roots of badly affected bushes are also abnormal, being long and weak, with relatively few lateral branches. Probably, in the tea bush, as in other plants, the symptoms of potash deficiency will be found to vary according to the available supply of nitrogen, and will thus be aggravated by heavy nitrogenous manuring.

Potash, in the form of its soluble salts, is one of the essential elements for plant growth. It occurs chiefly in the young growing parts of the plant, and to keep these supplied a certain amount is normally withdrawn from the older wood and from the fully grown leaves, as they reach maturity. It is for this reason that a deficiency of potash is felt first by the older leaves, the effect is one of premature ageing due to the increased withdrawal of potash to the growing parts. Potash salts appear to exert an influence especially on the water relationships of the plant and the "scorching" of the foliage from the margins and tips inwards is believed to result from an inadequate uptake of water under conditions of potash deficiency. The relation between potash supply and the nitrogen economy of plants is very striking: a shortage of potash causes an accumulation of soluble nitrogenous compounds in the leaf. Growth and assimilation, *i.e.*, the manufacture of organic food materials, are quickly retarded by a deficiency of potash, but are also soon retarded by an excess over the optimum requirement, and this is probably the explanation of the decrease in yield sometimes resulting from the application of potash fertilisers.

SAND CULTURE EXPERIMENTS

Tea seeds were germinated in washed quartz sand and the seedlings transferred to glazed earthenware pots containing the same material to which were supplied nutrient solutions of known composition. During the first growth period, from transplanting the seedlings at the end of 1937 until they were pruned in May 1939, there

was little difference between the plants receiving no potash and those receiving the complete nutrient solution. (It must be remembered that a limited supply of all elements necessary for growth is provided in the stored food materials of the seed). After pruning, however, the "potash-free" plants developed typical deficiency symptoms, and their growth was considerably reduced.

FIELD OBSERVATIONS

In the early stages of potash deficiency, the plantations appear more or less normal and the yield is not affected. A certain amount of blight (*Pestalozzia*) is usually to be found and the woody growth is rather poor. However, a deterioration soon sets in and the bushes develop a thin appearance due to the loss of their lower leaves, as already mentioned. This commonly happens first towards the end of the pruning cycle. Wood formation is progressively worse and the leaves develop the characteristic symptoms in abundance. Eventually, the bushes die out after pruning. Whole patches may be affected, or isolated diseased bushes may survive.

The soil types on which potash deficiency symptoms occur in West Java can be described briefly as much weathered, lateritic soils derived mostly from andesitic material, *i.e.*, from sub-basic volcanic rocks containing from 50-60 per cent of silica. They are reddish to yellowish brown in colour and are freely pervious. Potash deficiency is found on these soils at all altitudes from 500 to 3,500 feet above sea level. It has not so far been observed on the younger sandy soils of volcanic origin, occurring on the higher mountains, nor on the typical marls. On the west coast of Sumatra, however, sandy or loamy mountain soils appear to be affected, but relatively little work has been done in this region.

In West Java, observations and experiments were carried out in four different areas. These are briefly described below.

(a). *West of Tybadak*.—In this district, the contrast between highly productive and badly affected, almost useless estates was most striking. All stages in deterioration could be seen in a short journey. A preliminary experiment showed conclusively that recovery could be effected, (*i.e.*, provided an excessive number of deaths had not already occurred) by a sufficiently heavy application of a complete fertiliser mixture. The quantity of mixture stated to give satisfactory results was 300 grams per plant, which can be taken to represent some 130 lbs. nitrogen, 200 lbs. phosphate and 200 lbs. potash per acre. A less generous application, of 75 grams per plant, produced little or no improvement. A further experiment was planned to investigate the effect of applying potash fertilisers only, but this was spoilt by a severe attack of *Helopeltis*.

(b) *The Plateau of Soekanegara and Njalindoeng*.—Here the results of a manurial experiment running for the past ten years were available and the following difference in potash status could be distinguished among different plots: (1) Definite symptoms of potash deficiency seen, (2) No visible deficiency symptoms, but considerable response to potash manuring, in yield, (3) Slight response to potash manuring only, (4) Adequately supplied with potash with no further response to additional amounts.

(c). *Western Outliers of the Boerang Range*.—An experiment on nursery plants was undertaken on an estate showing severe symptoms of potash deficiency. Growth as measured by the average height of the plants and the weight of prunings at the end of the experiment was best on those plots receiving the complete mixtures of 100 grams (about $3\frac{1}{2}$ ounces) sulphate of ammonia, 50 grams superphosphate (or 90 grams rock phosphate) and 50 grams muriate of potash per square metre of about 25 plants, *i.e.*, about $\frac{3}{4}$ lb. of potash per square yard. Although none of the nursery plants showed definite symptoms of potash deficiency, those receiving potash were noticeably more free from "blight" and of a brighter green colour than any of the others.

(d). *North of Buitenzorg*.—An experiment was set up on a severely affected estate at less than 200m. elevation.

Four manurial treatments were given, as follows:—

- (1). No Manure — O.
- (2). Complete manure NPK (75g sulphate of ammonia, 50g. superphosphate, 50g. muriate of potash, per plant) (*i.e.*, about 330 lb. potash per acre).
- (3). No Potash — NP (do. muriate of potash omitted).
- (4). No Phosphate — NK (do. superphosphate omitted).

The plants were pruned at the beginning of the experiment and manured immediately and again after three months. The effect of potash was clearly visible in the condition of the plants as they came back from pruning, while a record of the first ten plucking rounds gave the following total yields expressed as percentage of the yield from the unmanured plants:—

N.P.K. 145% N.P. 119% N.K. 161%

Symptoms of potash deficiency in the plants receiving no potash were aggravated by plucking, owing to the removal of that element in the flush.

(e). *Observations in West Sumatra*.—As mentioned above, symptoms of potash deficiency have been observed here also. While the situation is not yet fully worked out, it appears that striking increases in yield have resulted from the application of potash fertilisers.

The following results are typical of an experiment in this region:—

	PRODUCTION OF FRESH LEAF		WEIGHT OF PRUNINGS	
	Jan. '36—May '38.	May '38—Sept. '39.	May 1938.	Sept. 1939
No Manure	100%	100%	100%	100%
N only	114.5	114.2	110.2	114.2
N.P.	120.0	119.5	121.1	119.5
N.P.K.	146.0	153.4	216.3	210.6

It is noteworthy that addition of potash to the fertiliser has had considerably greater effect, in each growth period, on wood formation than on leaf production.

DEFICIENCY SYMPTOMS IN RELATION TO THE POTASH CONTENT OF THE LEAF AND OF THE SOIL

From all the experiments in the different areas described above, soil and leaf samples were taken for chemical analysis, with a view to establishing the relation, if any, between their potash content and the presence or absence of deficiency symptoms or manurial response to potash in the crop. While for the soil samples, the methods of sampling and analysis follow a more or less well established technique, the leaf analyses present certain peculiar difficulties. The biggest of these will at once be apparent from a consideration of the changing potash content of the leaves at various ages. As already mentioned, this is highest in the young, actively growing stage and decreases with increasing maturity. Various earlier attempts to predict manurial deficiencies from the ash analysis of the leaf — the so-called “foliar diagnosis” method — have probably failed owing to lack of appreciation of this fact.

The present authors have used only fully grown, mature (but not moribund) leaves for their analyses, and although the precautions adopted in sampling these are not stated in detail, their results indicate that the difficulties were satisfactorily overcome.

Taking all the results together, the conclusion emerges that provided the physiological age of the leaf is taken into account, in the manner indicated, the potash content of the leaf can be used as a reliable indication of the potash status of the plant. The following figures show the ranges of potash content observed in the ash from samples of leaves of various external appearance:—

Severely affected (Marked deficiency symptoms)	...	4.4%- 9.6% K_2O
Slightly affected (slight do.)		9.0%-19.0% ,,
Healthy	17.0%-44.0% ,,

Thus with less than 10 per cent of potash (K_2O) in the ash, or non-combustible residue of the leaf, the leaf is definitely diseased; with more than 20 per cent, it is healthy. However, the content of other elements, especially nitrogen, is of importance in certain instances. In tea, the authors state that by heavy application of nitrogenous and phosphatic fertilisers potash deficiency symptoms could be induced which were not accompanied by any abnormally low content of potash in the ash. Generally speaking, potash deficient plants have a relatively high nitrogen content, which, however, they are not able to make use of until the deficiency of potash is made good. Their phosphate content is usually only slightly lower than that of the normal leaf, while the total amount of ash present remains about the same, the balance being made up by increased quantities of magnesium (MgO) and, presumably, sodium (Na_2O).

The potash content of the soil samples is conveniently expressed as the percentage of potash by weight of air-dry soil, extracted by means of 25 per cent hydrochloric acid. Here again, although a wide range of variation exists, the potash content of the soil is a reliable indication of its potash status in relation to the growth of the tea bush. In this case, the soils are grouped according to the occurrence of deficiency symptoms or the existence of a crop response

to potash manuring. The following percentages were obtained:—

Both potash deficiency symptoms and a response
to potash manuring: .003% to .007% K_2O

No deficiency symptoms, but response to potash
manuring: .009% to .017% K_2O

Do. no response to potash
manuring: .016% to 0.58% K_2O

Thus, potash deficiency symptoms will occur if the percentage of potash in the soil (estimated as above) is less than about .007 per cent, while a beneficial effect of adding potash fertilisers may be expected on soils containing up to .017 per cent of potash. The authors are careful to state that these percentages will hold good only for the soil types to which their observations are confined. On different soils, quite different limits may be found.

As might be expected from the foregoing results, the potash content of the leaf is susceptible of modification within wide limits by the amount of potash available in the soil. With soils initially low in potash, a marked increase of potash in the leaf will be produced by an added supply to the soil. Thus, in the experiment carried out in the Buitenzorg district, already described, the potash content of the leaf was almost doubled (compared with the value from the unmanured plot) by a complete fertiliser mixture containing muriate of potash. On soils increasingly rich in available potash, this effect is rapidly diminished and it is probably negligible on soils in which the potash content exceeds .030—.040 per cent. This value is considerably higher than the limit (.017 per cent) above which no crop response to potash manuring can be demonstrated, and it suggests that the plant can accumulate potash in amounts appreciably in excess of its maximum requirements for growth and crop production.

Under exceptional conditions a low potash content may be found in the plant while in the soil it is relatively high. This is held to indicate a disturbed uptake of potash from the soil, and the authors suggest an examination of the soil profile for signs of pan formation or other conditions for which a remedy can be sought in improved cultivation.

NOTE ON 'POTASH DEFICIENCY IN TEA CULTIVATION' IN RELATION TO CEYLON CONDITIONS

T. EDEN

The following addendum to Dr. Bond's review of the research carried out at the Proefstation voor de Thee, West Java, is based on results which the Agricultural Chemistry Department has been accumulating from the multiple factor experiment on nitrogen, potash and phosphate which, as far as the first two nutrients are concerned, has been in operation since 1930. These results are at present very far from complete. Their history is as follows: After six years of experimental treatment (*i.e.*, at the end of the pruning cycle ending in April, 1937) samples of pruning leaf and pruning wood were taken from the fifty-four plots of which the experiment consists. Their original purpose was to contribute to our knowledge of the nitrogen balance sheet of the experiment, a preliminary example of which was given in the annual report for 1934, Bulletin No. 12, p. 46. The experiment is a fully replicated one, there being a total of 18 plots devoted to each of the three levels of nitrogenous and potash manuring that form the basis of the trial.

On this occasion only nitrogen analyses were carried out on the whole range of samples. These analyses showed that manuring with nitrogen and potash respectively produced small but consistent changes in the nitrogen content of the leaf. The differences in values were not sufficiently great to be indisputably reliable, but they indicated a distinct possibility that addition of nitrogen as manure increased the nitrogen content of the foliage leaf, and that increments of potash had the opposite effect. This tentative conclusion is borne out by the Dutch work which shows a corresponding increase in nitrogen content under conditions of potash deficiency or, where deficiency symptoms are not actually in evidence, on plots where potash supply is at a minimum.

As a result of these data a limited number of potash analyses were carried out on the same material. These were restricted to the two sets which received

- (a) the highest nitrogen and the lowest potash
(N. 40 lb. per acre ; Potash nil)
- (b) the lowest nitrogen and the highest potash
(N. nil ; Potash 40 lb. per acre)

These showed small but entirely reliable increases in potash content of the leaf where potash fertilisers were given and nitrogen withheld. Expressed in the same terms as are used in the Java paper, *i.e.*, percentage of potash in the ash, there was an increase under the stated conditions from 13.26 per cent for (a) to 17.12 per cent for (b). This again is in agreement with the Java results.

The paper under review states limits for potash content of the leaf which define conditions of both deficiency and sufficiency judged according to foliage symptoms. How far these can be taken as valid under our conditions is problematical. But assuming that the conditions of sampling were similar (the Java paper does not define mature leaf) it is noteworthy that the samples from our plots that had been without potash manuring for six years, are still above the level set for a definite deficiency symptom; whilst those receiving potash fall within a range that includes both healthy and slightly affected bushes. The high potash contents quoted in the paper for healthy leaves are achieved only as a result of prodigiously heavy manuring (330 lb. of potash per acre or the equivalent of 660 lb. of muriate of potash.)

On the subject of soil values we have no comparable indications. Such analyses as we have carried out have not been done by the corresponding chemical method, and therefore do not offer a basis for discussion. Symptoms such as the Java paper describes are not prevalent in Ceylon. They are so characteristic of potash starvation, as understood in such crops as fruit and potatoes, as to have made their detection inevitable had they been common. In confirmation of this the results of the pruning weighments at the end of the 1937-40 cycle may be quoted. Whereas in Java potash deficiency reduces the prunings by more than 50 per cent the difference caused in our case is only 2.5 per cent.

At the date of receipt of the Java paper a full set of analyses for nitrogen, potash and phosphate was in progress for the more recent cycle, 1937-40. This cycle should show up even more clearly any compositional defects as regards potash in foliage leaf. The results will be reported in due course along with corresponding soil data. In the meantime, in view of the potash fertiliser situation, we may say that since nine years' cessation of manuring with potash have not diminished yield of flush nor wood and have not reduced over a six-year period our foliar diagnosis figure to the deficiency level, there is little danger to be anticipated in Ceylon from the lower degree of potash manuring that is at present unavoidable.

MINUTE AMOUNTS OF CHEMICAL ELEMENTS IN RELATION TO PLANT GROWTH*

During the past few years there has been a reawakened interest in the so-called minor elements and their effect on the growth and development of plants and animals, and their relation to malnutrition and disease. This renewed interest may be attributed to the notable advances that have been made since 1920 in our scientific knowledge of plant and animal nutrition, for many of these advances have been made possible only because of the recognition and experimental control of organic and inorganic substances in micro-quantities. Actually, as early as 1869, some researches were carried out on manganese and zinc, and their effects on plants were fairly well worked out, but the significance of the investigations was overlooked and for a long period the standard teaching still held that only ten chemical elements (nitrogen, phosphorus, sulphur, calcium, magnesium, potassium, iron, carbon, hydrogen and oxygen) were generally indispensable for the growth of higher plants. Many other chemical substances, if found to be effective at all, were regarded merely as plant stimulants or poisons. In 1914, the requirement for normal growth of maize plants of chemical elements not included in the list of ten was demonstrated by controlled water-culture experiments, but scant attention was paid to these investigations until much later, nor did appreciation immediately follow of the significant discovery, in 1923, that boron played an essential rôle in the growth of the broad bean and several other plants. It is therefore only comparatively recently that the relation of certain minor elements to some of the physiological "diseases" of plants has been definitely recognised, although research on this subject began many years ago.

The investigator of the nutrition of higher plants such as are able to grow in solutions of purely mineral character, has the advantage of a technique not available to the investigator of animal nutrition. An appreciation of this advantage, coupled with a growing recognition of the important part played by the minor elements in plant nutrition, has led to extensive investigations and, in recent years, many important discoveries have been made. In 1923, it was

* This article is based on a paper by D. R. Hoagland (*Science*, Vol. 91, No. 2372, pp. 557-560, 1940) and is reprinted from *Tropical Agriculture*, 1940, xvii, pp. 181-3.

shown that manganese was an indispensable component of a satisfactory nutrient solution. Later, during the period 1926-1931, certain experiments conducted with the use of highly refined technique led definitely to the conclusion that the varied species of plants studied could not complete their cycle, or indeed might show complete growth failure, in the absence of minute but determinable quantities of boron, copper and zinc, as well as manganese. More recently evidence has been adduced in support of the view that molybdenum is also one of the elements indispensable to higher plants. This does not complete the list of essential elements; there are, for example, indications that others should be added, but the evidence is not yet conclusive for complete indispensability for a wide range of plant species.

The term "minor" or "accessory," as applied to the chemical elements required in minute quantity, is somewhat misleading. These elements are as essential for growth as nitrogen, phosphorus and potassium, and the term "micro-nutrient elements" is much to be preferred. Although the effective amounts of the elements in question are not quite so exceedingly small as those involved in plant responses to certain vitamins and hormones, nevertheless extremely low concentrations produce visible effects.

Boron, manganese, copper and zinc are now generally accepted as essential elements, and the technique for growing plants under controlled conditions has advanced sufficiently to permit quantitative studies to be made on the effects of successive minute increments of these elements. To prove decisively the indispensability of such elements for varied species of plants with different quantitative requirements, the utmost care must be taken in the refinement of methods of water or sand culture. At one time the question arose as to whether, in ordinary experiments in plant nutrition and especially in agricultural practice under natural soil conditions, the investigator need be concerned with elements like boron, copper, manganese, and zinc. This question can now be answered definitely. In the experiments of the plant physiologist conducted with special attention to these elements, their presence in adequate amounts depends on accidental factors such as choice of chemical materials, distilled water or culture vessels, which yield uncontrolled contributions of micro-nutrients. Earlier investigations on the effects of different nutrient solutions on plant growth will therefore need re-examination in the light of this consideration.

Hundreds of reports published during the past few years in many parts of the world show that, under certain field conditions, crop plants may fail to make normal growth, or may become diseased, through deficiency of boron, copper, manganese or zinc. Especially

numerous are instances of boron deficiency to which commercially important diseases of the sugar beet, celery, apple, alfalfa and many other crop plants are attributed. Frequently such boron deficiencies have been corrected economically by application to the soil of boron containing compounds. It should be borne in mind, however, that those elements essential for plants in minute amounts may also become toxic at concentrations in the nutrient medium which are still very small. The physiological range is sometimes relatively narrow, so that, in many cases, extremely small increases in one or more of these essential elements, over and above the small quantity required by the plant, are definitely harmful. As an example, some irrigation waters may add to the soil sufficient boron to cause severe injury to sensitive crops; this has raised an important economic question in some areas.

As another illustration of deficiency causing plant disease, it has been shown that previously obscure nutritional disorders of fruit trees, such as "little leaf," "mottle leaf" and "rosette," are the results of a deficiency of zinc, minute as the requirement is. It was at first difficult to believe that a simple zinc deficiency was involved for, to cite a specific case, a peach orchard was found to be diseased although growing in soil containing within the root zone a total of approximately 3,000 pounds of zinc per acre, of which the trees, at seven years of age, had removed only about one half pound. Nevertheless, controlled experiments by water-culture technique, and other evidence, proved that zinc deficiency was indeed the cause of the disease. This naturally raises the difficult question as to what factors govern the availability to plants of zinc in the soil. Some experiments suggest that, at least in certain soils, this availability may have a relation to the growth of soil micro-organisms which may themselves absorb zinc.

There is another type of "disease" that may affect fruit trees in the field caused by deficiency of copper. Here also similar symptoms have been reproduced in plants growing in culture solutions lacking only copper. Manganese deficiencies for various kinds of plants under field conditions are also well known, and can be reproduced under controlled conditions.

These are only illustrations of the significance to agriculture of chemical elements effective in minute amounts. It should be emphasised that not all soils are deficient in the ability to supply these elements to the plant. Furthermore, when a deficiency exists, it does not necessarily follow that it will be corrected by the use of some fertiliser containing minute amounts of the element in question as an impurity. The chemical fixing ability of the soil

enters as a most important factor. In practice, deficiencies sometimes have to be corrected by direct application to the plant of the deficient element by spraying, by injection, or by some other means.

Research on the micro-nutrient elements has been followed rapidly by practical applications, but this research is still inadequate in that our knowledge of the functions of mineral micro-nutrients in plant metabolism is extremely limited. A deficiency of boron exerts profound effects in the meristematic regions of the plant, yet there is apparently no really satisfactory hypothesis concerning chemical reactions in the plant in which boron might assume an indispensable rôle — a rôle which appears to be specific to boron, as very extensive experiments with other chemical elements have demonstrated.

Outstandingly important advances have been made in general research on oxidation-reduction systems in living organisms and these may lead to an understanding of the functions of the mineral micro-nutrients. Thus, the oxidation of carbohydrates involves intricate enzyme systems in which hydrogen carriers have a place, and it is possible that such oxidations are catalysed by metals outside the cells. Recently copper has been reported as an essential component of certain oxidase systems which are of importance in plants, and there is evidence that manganese is essential to respiration and nitrate reduction in the plant. It is also possible that a zinc protein enzyme catalyses the splitting of carbonic acid to water and carbon dioxide. A secondary effect of zinc deficiency on the content of auxin growth substance in the plant has also been observed, the zinc-deficient plants showing much less auxin activity than those having an adequate supply of zinc. In general there appears to be ample justification for the assumption that minute amounts of inorganic elements and minute amounts of organic substances may frequently be inter-associated in their actions. It should therefore be feasible to study some of the possible relations of micro-nutrient elements to the synthesis of vitamins or their precursors by the plant.

Deficiencies in essential metallic elements commonly produce chloroses of various types in green plants, but quite apart from such marked failures of chlorophyll synthesis, the essential elements may also have an effect on photo-synthetic efficiency. This has not yet been proved, but the results of studies on *Chlorella*, undertaken with a view to investigating factors influencing the efficiency of photo-synthesis, are highly promising. By the technique adopted in these experiments, it was found that the utilization by *Chlorella* of certain combinations of micro-nutrient elements coincided with increased light-absorbing ability on the part of the plant. Whatever

the final interpretation of these experiments may be, the general question is of great interest as to what concentrations and relations of metals in the green cell are conducive to the largest synthesis of sugar permitted by other factors in the environment.

Workers in animal and plant nutrition are finding common interests in their researches on minute factors in cell metabolism, especially since it has been recognised that certain animal deficiency "diseases" may be traced to lack of micro-nutrient elements in crops and soils. Investigators are now seeking to discover how the environmental factors influencing the composition of the plant are related to its value as a food for animals; in other words, how do climate, soil and manure affect nutritional quality. An interesting example of a differential requirement for plant and animal is that of the cobalt-deficiency disease of sheep and cattle which has been extensively studied in New Zealand and Australia. The cobalt-deficiency in certain soils did not diminish the growth of pasture plants, but the animals suffered from lack of cobalt in the ration. Apparently, deficiency of copper for the needs of animal nutrition may also occur in various regions, while manganese deficiency certainly requires further study.

There exists, on the other hand, the possibility that the plant might absorb special mineral components of the soil in such amounts as to produce a toxic foodstuff. Some species of plants growing in selenium-containing soils absorb so much of this element that the plant becomes severely toxic to the animal. It is an interesting aspect of plant physiology that ability to accumulate selenium from the same soil varies strikingly among different species of plants. Plants may also absorb fluorine, arsenic and other toxic elements when naturally present in, or added to, the soil.

The extensive literature that has grown up around the subject of micro-nutrient elements well illustrates the remarkable number of investigations that have been carried out since the important part played by these elements was first appreciated. A bibliography of the subject, compiled in 1935 and 1936, revealed about 3,000 references to some 30 minor elements which were classified into those known to be essential to plants, those unessential, and those that are doubtful. The investigation of soil and plant interrelations and its bearing on problems of animal nutrition is so difficult that lengthy and patient co-operative research on the part of plant and animal physiologists, soil chemists, and plant breeders will be needed completely to elucidate them.

REPORT ON THE SMALL-HOLDINGS COMPETITION IN THE SOUTHERN PROVINCE—1940

T. EDEN

The competition was held in that part of the Gangaboda Pattu that is in the neighbourhood of Wanduramba.

The final selection was made during the week commencing December 9th, and the prize distribution was held on December 14th at the Wanduramba Government Boys' School. The Agricultural Chemist who had judged the competition presided, supported by the Mudaliyars of the Gangaboda Pattu, and the Bentota division, and the Chairman and members of the Wanduramba Village Committee. A large number of small-holders attended. For the second year in succession the Wanduramba Village Committee showed its interest in the small-holdings' work by contributing half of the prize money.

GENERAL PROGRESS

The number of competitors was disappointingly small, only some 6 per cent. of the holders on the register taking part. This apparent apathy on the part of the small-holders was offset by the quality of the work done by those whose interest had been roused. The progress reports of the officer-in-charge show that even these required a great degree of persistence in visiting before steady and consistent progress was established.

A comparison between this competition and that in the Central Province (*The Tea Quarterly* Vol. XIII, p. 124) is of interest. There can be little doubt that the economic level of the small-holders in the present competition is superior to that in the Gampola district. In the latter area the small-holders' effort is to all intents and purposes confined to his own labour, supplemented by occasional hiring of outside help for such operations as pruning. In the Southern Province there was frequently evidence of money having been spent on the holdings in the form of manuring. The holdings here are on the whole better. I have seen in certain parts of the Gampola-Peradeniya area excellent stands of good jât tea, but they are not characteristic of the area as a whole. In the Gangaboda Pattu the jât is conspicuously good as a whole,

Further evidence of superior economic conditions is the ownership of cattle, a state of relative affluence unknown in the other area where the Institute has similar work. The difference in general conditions extends to matters of detail as set out later in this report. One feature of note was that the small-holders in this competition had not been content with progressive work in only one or two directions. Practically every method within their means had been tried.

DRAINS AND TERRACES

The terrain is generally easier than at Gampola, and there is an abundance of stone. This makes drain construction difficult at times, but is compensated by the possibility of constructing terraces. All sorts of these were to be seen. Many were of long standing efficiently repaired; some were new, and in specially difficult places individual bush terraces were made. Drains varied in construction according to the lie of the land. Some were reverse sloped; others were of the lock-and-spill type; still others were silt-pitted. Great care had been spent in many cases in attention to details such as turfing the lip of reverse slope drains and providing a stone block at the bottom of the spill to prevent scouring. Main drains had received special attention and were in good order. Some of the holdings adjoined rubber land. Here deep boundary drains had been dug which served the dual purpose of intercepting the extension of rubber roots into the holding and leading away storm water from higher land.

SHADE TREES AND GREEN MANURING

The benefits of shade trees and their loppings were generally appreciated. New plantings were frequent and on older trees instruction in training them to proper shape had made some impression. Bush green manures had been tried, but their success was so doubtful that it is a question whether their usefulness will justify the expense of seed.

SUPPLYING

This operation was well in hand. On the whole the holdings seen were not markedly deficient, judged by a small-holdings standard. Some supplies were stumps, others seed-at-stake. There was a conflict of opinion on the merits of the two methods. On general principles seed would appear the better,

PRUNING AND PLUCKING

Generally the system is that of a low cut-across, leaving 'lungs,' and the method appears suitable for the locality. There was little plucking being done, but I saw fields 18-24 months out of pruning with more reasonable plucking tables than is usual in small-holdings.

OTHER CROPS

I saw no inter-planting with annual crops. On the whole the stand of tea is good enough to cover a fair proportion of the ground thus making inter-planting less attractive. Some coconut palms were visible and many holders had been persuaded to remove them. An occasional jak tree seemed to have no markedly deleterious effect on the surrounding tea.

MANURING

Small-holders are accustomed to using small quantities of bone meal on their paddy and quite a fair proportion buy it for their tea. In view of our general experience this manure is not a highly profitable investment since it is chiefly phosphatic. At the locally prevailing prices coconut poonac would be better because it supplies as much nitrogen bulk for bulk, gives sufficient potash and phosphate, and is cheaper.

The ownership of cattle has made composting possible. Subject to warnings about the extravagant use of ash this is to be encouraged. I saw some useful pits and one excellent cadjan covered installation.

There now exist in this neighbourhood some 15 excellent demonstration holdings that are a credit to the holders and their instructor. The main requirement is for other holders to copy them. Borrowing Dr. Child's useful metaphor, small-holdings require not a "miraculous draught" in the shape of coupon money, "but an astringent tonic labelled — work."

STUDIES ON THE FIRING OF TEA—II

J. LAMB

INTRODUCTION

In the first article ⁽¹⁾ of this series an account of experiments on firing temperatures was given. The objects and experimental method were set out at some length and reference should be made to that article for detail.

Experiments concerned with the effect, at different seasons, of firing tea at 160°F., 190°F. and 210°F. under conditions of (a) Constant load and air flow and (b) Constant time and air flow, have been completed and the results form the subject of this article. Since the first article was published it has become impossible, owing to war conditions, to have samples tasted in London but we have been fortunate in having the advice of our usual Colombo Team of Tasters and the results are so very definite that the question of market requirements does not arise.

The present results incorporate those given in the previous article. Values for Flavour and Pungency are omitted from Tables I and II since Colombo Tasters have not reported either property. The Colombo Tasters never report pungency in St. Coombs teas and flavour only when it is outstanding, whereas London Tasters are often of the opinion that some pungency and flavour are present. Such differences are in degree only and are easily taken into account when analysing results so long as the Teams are consistent, as they have been to a marked degree. The London Tasters, as reported in the previous article, ² were very definitely of the opinion that the degrees of pungency and flavour observed depreciated as the firing temperature was raised. Pungency and quality were marked down severely in teas fired at 210°F.

RESULTS

The complete results are set out in Tables I to IV. As already mentioned they incorporate all previous results. The figures shewn in Tables I and II are the conclusions drawn from sixty-four team reports on sixty-four sets of teas, each set being a well mixed bulk of the teas from three separate experiments. This means that the experiment of comparing firing at 190°F. with firing at 160°F.

and 210°F. has been repeated at least ninety-six times, each lot of samples having been tasted twice, *i.e.*, before and after storage.

During the analysis of team findings very rigorous methods of selection and rejection have been employed with the result that any differences reported in the Tables have been very marked and agreed upon by all the Tasters. All small differences have thus been completely ignored.

COLOMBO VALUATIONS

TABLE I

Load and air-flow constant (Time varied)

N. E. MONSOON SEASON

Temperature °F.	Analysis				Valuation in cents	Analysis after storage*				Valuation in cents after storage*
	Appear- ance	Col- our	Strength	Qual- ity		Appear- ance	Col- our	Strength	Qual- ity	
160	0	0	0	0	0	0	0	0	0	+1
190		Standard					Standard			
210	0	0	0	-1	-3	0	0	0	0	-1½

* Storage for 2 months.

DRY-WEATHER SEASON

160	0	0	0	+1	+2½	0	0	0	0	+1
190		Standard					Standard			
210	0	0	0	-1	-2	0	0	0	-1	-2

INTER-MONSOON SEASON

160	-1	0	0	+1	+2½	-1	-1	0	0	-2
190		Standard					Standard			
210	0	0	0	0	-2	0	0	0	-1	-4

S. W. MONSOON SEASON

Temperature. °F	Analysis				Valuation in cents	Analysis after storage				Valuation in cents after storage
	Appearance	Colour	Strength	Quality		Appearance	Colour	Strength	Quality	
160	-1	0	0	0	0	-1	-1	0	0	-2
190		Standard					Standard			
210	0	0	-1	-1	-4	0	0	-1	-1	-4

VALUATIONS FROM LONDON

TABLE III

Load and air-flow constant (Time varied)

N. E. MONSOON SEASON

Temperature °F	Analysis						Valuation in farthings
	Appearance	Colour	Strength	Pungency	Quality	Flavour	
160	0	0	0	+1	+1	+1*	+2
190			Standard				
210	0	0	0	-2	-2	-1*	-3

INTER-MONSOON SEASON

160	0	0	0	0	0	—	0
190			Standard				
210	0	0	0	-1	-1	—	-1

* Reported in 1 sample only

TABLE IV

Time and air-flow constant (Load varied)

N. E. MONSOON SEASON

Temperature °F	Analysis						Valuation in farthings
	Appearance	Colour	Strength	Pungency	Quality	Flavour	
160	0	0	0	0	+1	+1*	+2
190			Standard				
210	0	+2	0	-3	-3	-1*	-4

INTER-MONSOON SEASON

160	0	0	0	0	0	—	-1
190			Standard				
210	0	-1	0	-1	-1	—	-3

* Reported in 1 sample only

DISCUSSION OF RESULTS

The results are very clear and little explanation is necessary. It is interesting to note that when the appearance of the (fresh) teas fired at 160°F. was marked down one point, the same adverse opinion was given when the same teas were put before the Tasters six weeks later after storage. Teas fired at 160°F. are not quite so black in appearance as those fired at higher temperatures and this probably accounts for the difference reported. However, this is not an important fact as temperature of firing does not affect the appearance of teas to any significant extent; the interest lies rather in the careful attention paid by Colombo Tasters, as often before pointed out, to differences in appearance, and in the consistent nature of our "Team" reports. In the latter connection it may be recalled⁽³⁾ that samples received by the team are identified by a number only and they are not even aware, when tasting, that the samples are connected with firing experiments.

The main effect of firing temperatures is obviously upon quality. On an average of twenty-seven out of thirty-two occasions quality

was to a marked extent adversely affected by firing at 210°F. As a result of this the valuation of the teas were affected in the following way:—

160°F.	resulted in higher values than	190° or 210°F.	on 40 occasions.
190°F.	"	"	160° or 210°F. on 19 "
210°F.	"	"	160° or 190°F. on 0 "

Firing at 160°F. undoubtedly results in the best teas but, despite the accurate control over moisture content and storage conditions which is possible on an experimental scale, there were distinct signs of lack of keeping quality in the low fired teas. On an average of eighteen out of thirty-two occasions the margin of valuation in favour of teas fired at 160°F. depreciated after two months' storage. This is probably more than could be due to chance or to market conditions. Depreciation of valuation on thirteen of these occasions resulted in the teas fired at 160°F. being valued after storage, at less than those fired at 190°F.

It must be concluded therefore that the keeping quality of teas fired at 160°F. is doubtful. The moisture contents of these teas did not exceed 5 per cent at any period.

Tables III and IV contain results of opinions given by London Tasters in the early stages of the experiments before the war interfered. Although not so complete as the results in Tables I and II they afford valuable confirmation. Quality and Pungency are marked down severely.

SUMMARY OF CONCLUSIONS

1. Experiments comparing teas fired under carefully controlled conditions in a single operation at 160°F., 190°F. and 210°F. have been completed.

2. Above 190°F. temperature has an adverse effect upon quality, and also upon pungency and flavour when reported. This adverse effect causes a loss of value, and firing temperatures above 190°F. have been found to be inadvisable.

3. Firing at 160°F. results in the production of teas of better quality and higher value (when fresh) than firing at 190°F. but they lack keeping quality even when thoroughly dried and carefully stored with the result that the practice of firing at temperatures below 190°F. cannot be recommended.

4. These results cover both firing with thin spreading in 21 minutes and with thicker spreading for longer periods up to 42 minutes. Double firing has not been studied in this series.

REFERENCES

- (1). *The Tea Quarterly* 1939, XII, 171.
- (2). *Ibid* 1939, XII, 178.
- (3). *Ibid* 1937, X, 57.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 24-10-40

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon held at the Ceylon Chamber of Commerce Rooms, Colombo, on Thursday, October 24th, 1940, at 3 p.m.

Present.—The Chairman, Tea Research Institute of Ceylon (Mr. James Forbes), the Acting Financial Secretary (Mr. C. H. Collins, C.C.S.), the Chairman, Planters' Association of Ceylon (Mr. R. C. Scott), the Chairman, Ceylon Estates Proprietary Association (Mr. C. H. Bois), Major J. W. Oldfield, C.M.G., O.B.E., M.C., Messrs. R. G. Coombe, J. C. Kelly, W. H. Gourlay, R. Gregor and Dr. C. H. Gadd (Acting Director and Secretary).

Letters expressing inability to attend were received from Mr. T. B. Panabokke, First Adigar, and the Acting Director of Agriculture (Mr. M. Park).

1. The Notice calling the Meeting was read.
2. The Minutes of the Meeting of the Board held on July 26th, 1940, were confirmed.

3. FINANCE

(i). *Institute's Accounts to 30th September, 1940.*—In reviewing the accounts the Chairman drew attention to the fact that the interest and capital payments due on the Government Loan on the 29th September had been duly made.

Mr R. G. Coombe asked that rainfall figures for the year together with those of the previous year to the same date should be included with the crop statement. This was agreed.

On the motion of Mr. R. G. Coombe, seconded by Mr. C. H. Bois, the accounts were accepted.

(ii). *Investments.*—The Chairman reported that, following advice of authorities at Home, he had instructed the National Bank of India to convert the Institute's Bearer Bonds, held by them, into Registered Bonds in the name of the National Bank of India Nominees Ltd.

The Board approved the Chairman's action.

(iii). *Estimates for Estate Lines.*—The Chairman reported that in accordance with the decision made at the last meeting, estimates for the erection of 12 line rooms in 3 groups of 4 rooms (Plan No. 30A) had been circulated to the Members of the Finance Sub-Committee. That Committee had approved the estimates of Sudu Appu Baas. As the site chosen was too small for the 3 groups of rooms it had been decided to proceed immediately with the erection of two groups and to submit estimates for the third group in the 1941 estimates.

The decision of the Finance Sub-Committee was confirmed.

(iv). *Application for Grant from the Colonial Development Fund.*—The Chairman reported that a reply had been received from the Secretary of State for the Colonies through Government channels indicating that their application had not been viewed with favour.

The Meeting decided to take no further action in the matter.

(v). *Contract for Supply of Tea.*—The Chairman reported that the Seal of the Board had been attached to a contract with the Tea Controller on the 4th September in the presence of Messrs. J. C. Kelly and C. H. Bois. The contract was for the sale of 2,500 lb. of fannings; approved at the Meeting on July 26th.

4. MILITARY SERVICE OF STAFF

The Chairman reported that Mr. R. L. Illankoon was mobilised on August 14th and had been on military duty with the Ceylon Light Infantry since that date.

Mr. C. B. Redman King would be mobilised on October 27th probably for a period of about 9 weeks.

The Chairman said that the general principles regarding officers' pay while on military service were decided at the Meeting of July 13th, 1939. No provision for a reciprocal undertaking by the officers concerned had been made. He suggested that officers released for military duty should be asked for an undertaking that they would return to the service of the Board when released from military duty unless physically incapacitated.

This was agreed.

5. SENIOR STAFF

(i). *Director's Leave.*—The Chairman reported that the Director proceeded on leave to India on August 7th and that Dr. Gadd had acted for him during his absence.

Dr. Norris had since asked to be allowed to extend his leave till the end of November.

The Board approved the extension asked for.

(ii). *Dr. Eden's Leave.*—The Chairman stated that Dr. Eden was due for leave on February 17th but had applied to advance his departure by one month for family reasons. The Acting Director supported Dr. Eden's application.

Dr. Eden's application was approved and he was granted 8 months' leave from about the middle of January, 1941.

6. ANY OTHER BUSINESS

St. Coombs Estate.—The Chairman said that he had made a thorough tour of the estate and was pleased to be able to report that it was in excellent condition.

C. H. GADD,
Acting Secretary.

NOTICES.

The Institute's Laboratories and Offices are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. M. Y. Hemachandra & Co., Forwarding Agents. *Carriage should be pre-paid.*

Visitors' Days.—The *second* and *last* Wednesdays in each month have been set aside as Visitors' Days at St. Coombs Estate, and also at the T. R. I. Sub-Station, Gonakelle Estate, Passara, when it is hoped anyone interested will visit the Stations.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

**RULES FOR THE OCCUPATION OF
ST. COOMBS GUEST HOUSE**

- (1). The Guest House is normally intended for the use of persons visiting the Institute and St. Coombs Estate on business. Children can in no circumstances be accommodated.
- (2). Permission to occupy a room for the night must be obtained from the Director in writing and, unless sufficient notice be given, accommodation cannot be guaranteed. Two double rooms are available for the use of visitors accompanied by their wives.
- (3). All visitors must sign the Visitors' Book on arrival.
- (4). A bedroom may not be occupied for more than one night if required by another visitor. This shall not apply to Members of the Board or of Committees meeting at St. Coombs who shall also be entitled to priority in the allocation of accommodation when on official business.
- (5). Complaints or suggestions shall be entered in the book provided for the purpose and not made to the Guest House Staff.
- (6). All payments due for services rendered shall be made in *cash* to the steward-in-charge and a receipt obtained from him on the official form. The scale of approved charges is posted in the building. The steward is forbidden to give credit or to accept cheques.
- (7). Liquor is supplied for consumption *in the premises only*.
- (8). The Institute accepts no responsibility for cash, jewellery or other valuables of any kind left in the Guest House
- (9). All breakages will be charged for at cost price.

ROLAND V. NORRIS,
Director.

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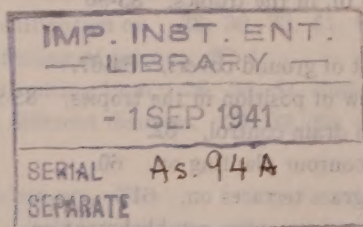
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The Tea Research Institute of Ceylon.

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- (8) Mr. T. B. Panabokke, First Adigar

(E) Ex-Officio Members:—

- (9) The Hon. the Financial Secretary
- (10) The Director of Agriculture
- (11) The Chairman, Planters' Association of Ceylon
- (12) The Chairman, Ceylon Estates Proprietary Association

Secretary, Roland V. Norris, D.Sc., St. Coombs, Talawakelle.

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